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EDITORIAL

THE STUDY OF THE NORMAL

We are often handicapped in our appreciation of pathological conditions by our lack of accurate knowledge of the picture of the normal: it is therefore of interest and importance that normal structures and functions should be fully studied. There is a definite move throughout the scientific world to encourage such studies and we believe that the time will come when the worker and observer of the abnormal will have at his disposal a full understanding of the normal with which to compare his results. We draw the attention of our readers to articles in this number of The Veterinary Journal which deal with such observations.

Much is now being written on cellular changes in blood and their aid to diagnosis of different disease conditions, sometimes associated with tissues other than blood. The morphology, numbers, etc., of such cells and the variations which may be found under "normal" conditions are not always known for the animal which is the subject of investigation. This often means that the worker has to define the "limits of normality" before he can assess the significance of his results: the present trend to deal with the "normal" animal should assist in this direction. The character of the cells in normal structures and their alteration in the abnormal should also be valuable in the diagnosis of some diseases in our domestic animals.

We would also reiterate our plea for detailed study of the normal processes and functions of the various body systems, especially those associated with reproduction. In our understanding of infertility in cattle we are meeting with difficulty all the time because we are not always in a position fully to appreciate the normal processes associated with the fertile animals. There is an extensive field of investigation to be opened up on this subject.

GENERAL ARTICLES

SOME OBSERVATIONS ON THE BLOOD LEUCOCYTE PICTURE DURING THE INTRADERMAL TUBERCULIN TEST: II—THE "SKIN-LESION" REACTOR

By G. H. ARTHUR

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In a previous paper (Arthur, 1946), the literature dealing with the application of hæmatological methods to the diagnosis of tuberculosis was reviewed. In addition, a description was given of the blood leucocyte picture during the comparative intradermal tuberculin test in both reacting and non-reacting cattle, using "Weybridge" tuberculin. Characteristic changes which comprised an increase in the total leucocyte count and neutrophilia, with a slight shift to the left, were found in reacting cattle. In a group of non-reacting animals no comparable changes occurred. It was then hoped that these blood changes might constitute a more specific indication of tuberculous infection than the skin reactions at the site of tuberculin injection, and that they would provide a means of differentiating the "non-specific reactor." An opportunity soon occurred to test this hypothesis in the case of four "skin lesion" reactors.

Animals Used

The subjects were four cows, three of which were in "Attested Herds" and one in a "Tuberculin-tested" herd. They had all shown no reactions to avian and mammalian tuberculins at several previous tests. At the last test immediately prior to this investigation, however, typical reactions occurred, with the mammalian skin measurements significantly in excess of the avian. A clinical examination was made, and all the cows showed "skin lesions."

In each case, the lesions were disposed in the form of a chain of nodular enlargements of the skin and subcutis which seemed to follow the course of a distended lymphatic vessel. The appearance of a series of 22 such lesions in cow No. 3T is shown in the accompanying photograph. In the three cows Nos. 3T, 1LH and 2LH, the lowest and largest lesion was a granuloma, the size of a walnut, on the metacarpus. These larger lesions later suppurated and discharged a creamy pus, in which acid-fast organisms were found. In the fourth case, cow No. 81HH, two nodules were excised under local anæsthesia and were found, on section, to contain purulent material in which acid-fast rods were present. The histology of the nodules was typical of a true tuberculous lesion, but the organisms could not be cultured on laboratory media.

At subsequent tests carried out after this investigation was completed, the tuberculin allergy of these animals waned, and they were adjudged to have passed the official test. It was of interest to note that the skin nodules enlarged during the tuberculin test and later regressed to pre-injection size.

Technique

The blood picture was studied at the first tuberculin re-test after the lesions were discovered. The technique of blood examination used was that previously

described (Arthur, 1946). The animals were bled prior to and twelve hours after the initial injections of 0.1 c.c. of avian and mammalian tuberculins (Weybridge P.P.D.).

Results Obtained

The total and differential leucocyte counts together with skin measurements, prior to and twelve hours after the initial tuberculin injections, are shown in Tables I and II respectively.

TABLE I.

Blood Leucocyte Picture and Skin Measurements at time of first injections of tuberculin.

Identification	Leucocytes c./mm.	Neutrophiles Bands. per cent.	Neutrophiles Polys. per cent.	Lymphs. per cent.	Monocytes per cent.	Eosinophiles per cent.	Basophiles per cent.	Skin Measurements mm. Avian	Skin Measurements mm. Mamm.
3T	6,750	1.0	23.5	64.5	3.0	8.0	0.0	6	7
81HH	7,500	2.0	28.0	56.0	5.0	9.0	0.0	6	5
1LH	6,850	9.0	16.5	68.5	0.5	5.0	0.5	8	8
2LH	7,650	4.5	25.5	56.5	3.0	9.5	1.0	7	8
	7,188	4.1	23.4	61.4	2.8	7.9	0.4	6.7	7.0

TABLE II.

Blood Leucocyte Picture and Skin Measurements 12 hours after the first tuberculin injections.

Identification	Leucocytes c./mm.	Neutrophiles Bands. per cent.	Neutrophiles Polys. per cent.	Lymphs. per cent.	Monocytes per cent.	Eosinophiles per cent.	Basophiles per cent.	Skin Measurements mm. Avian	Skin Measurements mm. Mamm.
3T	9,050	7.5	45.0	36.0	1.5	10.0	0.0	6	9SDP
81HH	7,350	14.5	30.0	37.5	3.0	13.5	1.5	10SD	7
1LH	10,300	20.0	23.0	50.5	3.5	3.0	0.0	8	8
2LH	10,650	14.5	25.0	52.0	2.0	6.5	0.0	8	10
	9,337	14.1	30.8	44.0	2.5	8.2	0.4	8	8.5

(a) *The total leucocyte count.*

The average initial count of 7,188 was raised to 9,337 at twelve hours after the tuberculin injections.

(b) *The differential count.*

Neutrophiles. The average initial count was 27.5 per cent., of which 4.1 were immature cells. Cow No. 1LH showed a relatively high percentage of immature cells—namely, 9—in the absence of neutrophilia. This may have been accounted for by the active suppuration of the metacarpal lesion.

At twelve hours after the tuberculin injections, the average neutrophile count was 44.9 per cent., of which 14.1 were immature cells. This represents neutrophilia with shift to the left.

Lymphocytes.—The initial percentage of 61.4 was lowered to 44.0 at twelve hours.

Monocytes.—Initial and post-injection percentages were 2.8 and 2.5 respectively.

Eosinophiles.—The initial average of 7.9 per cent. was slightly raised at twelve hours to 8.2 per cent. of the differential count.

(c) *Skin reactions.*

There were small increments in both the avian and mammalian skin measurements at twelve hours, but in no case did the animal finally react to the comparative tuberculin test.

Discussion

This investigation showed that the intradermal injection of tuberculin into four "skin lesion" reactors was followed at twelve hours by an increase in the total leucocyte count and by neutrophilia with shift to the left. These findings were, in fact, identical with those which occurred in a group of reacting cattle in a herd where bovine tuberculosis was prevalent (Arthur, 1946).

The "skin lesion" reactor, which is now more frequently recognised than formerly, is an example of a "non-specific" infection which gives rise to tuberculin allergy. Such cases cause confusion in the interpretation of the tuberculin test since the skin reactions when allergy is maximal may be indistinguishable from those which occur in an animal affected with bovine tuberculosis. This study has shown that the similarity in skin reactions to tuberculin injections in "skin lesion" cases and bovine tuberculosis is paralleled by identical changes in the blood leucocyte picture. It would seem, then, that the blood changes constitute but another manifestation of the allergic state of an animal. Some evidence was obtained in this investigation which tended to show that the blood leucocyte changes constituted a more delicate test of allergy than the skin reactivity. For instance, pronounced blood changes occurred in the absence of obvious skin reactions. In this connection, Hendershott and Johnston (1942) have already shown that by means of the blood changes they were able to identify tuberculous animals before they had developed the capacity to give positive skin reactions. In the presence of non-specific infection, however, it is highly probable that a positive blood reaction would occur also and hence lead to the needless slaughter of a non-tuberculous animal. In reasoning by analogy with the "skin lesion" reactor, the results of this investigation illustrate that a study of the blood leucocyte picture in conjunction with the tuberculin test is unlikely to aid the differential diagnosis of tuberculous infection and "non-specific" infections due to other acid-fast organisms. In so far as detection of the skin lesion case is concerned, the best means available at present consist in a study of the herd history and a rigorous clinical examination of reactors for skin nodules at the time of the tuberculin test.

Summary

Total and differential leucocyte counts were made before and at twelve hours after the initial injections of avian and mammalian tuberculins in four bovine "skin lesion" cases.

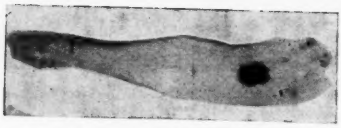
The changes in the blood picture, which comprised an increase in the total leucocyte count and neutrophilia with shift to the left, were identical with those which occurred in true tuberculous reactors.

The significance of this finding was discussed and it was concluded that a

Cow No. 3T.

(Article by G. H. Arthur.)

PLATE I.



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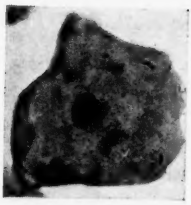

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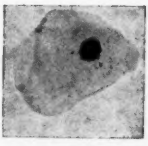

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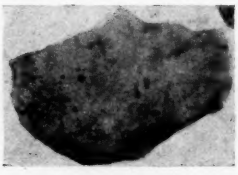

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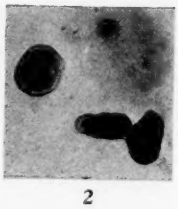
7

Cells from superficial layers (× 500).

1



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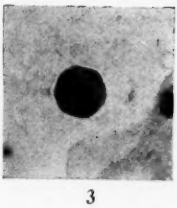

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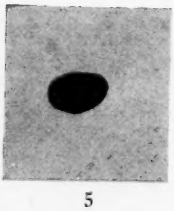

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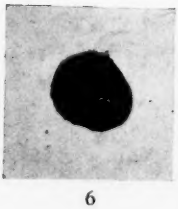

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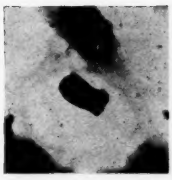
Cells from middle layers (× 500).

(*Article by Haq and Rollinson.*)

PLATE II.

1



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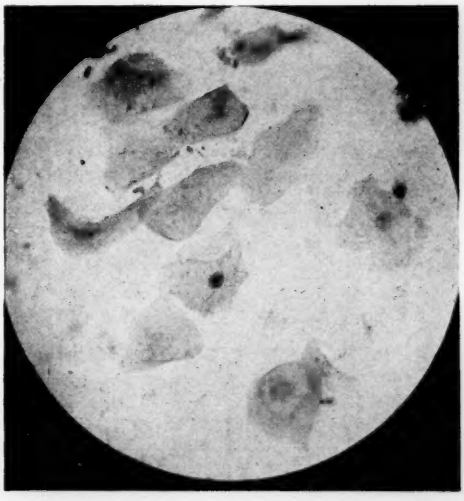
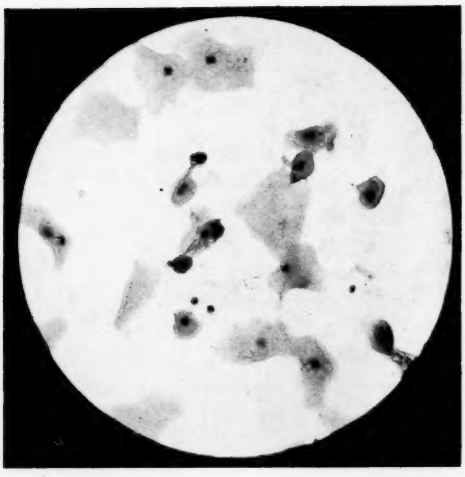
5

Cells from basal layers (× 500).

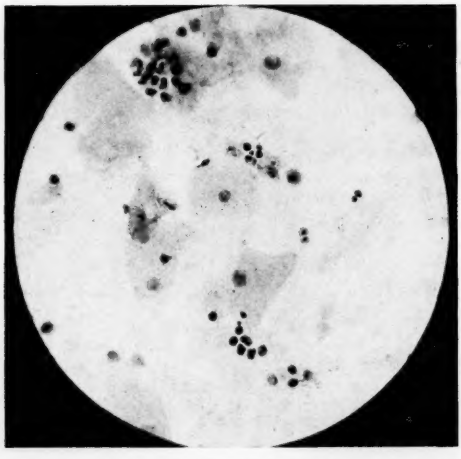


Cell picture in healthy condition of the prepuce, showing only large cells from superficial layers and vegetable debris (×250).

(Article by Haq and Rollinson.)



Cell picture in deep-seated inflammation of the prepuce, showing large cells from superficial layers and small cells from middle and basal layers (× 250).



Cell picture in superficial inflammation of the prepuce, showing pus corpuscles and large cells from superficial layers (× 250).

(*Article by Haq and Rollinson.*)

study of the blood picture during the tuberculin test was not of value in the differential diagnosis of bovine tuberculosis and "non-specific" infection.

Acknowledgments

Thanks are due to Dr. G. O. Davies for a description of the histology of the skin lesions, to Mrs. I. W. Jennings, M.R.C.V.S., for a report on the bacteriological examination of them, and to Mr. H. A. Crawshaw, B.Sc., F.R.C.V.S., for the photograph.

REFERENCES.

Arthur, G. H. (1946): *Vet. J., 102,* 147-157.
Hendershott, R. A., and Johnston, C. B. (1942): *Proc. 45th Ann. Meet. U.S. Live Stk. Sanit. Assoc.,* 157-169.

EPITHELIAL CELLS IN THE PREPUTIAL WASHINGS OF BULLS

By I. HAQ and D. H. L. ROLLINSON
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Introduction

DURING the course of investigation into causes of sterility in bulls, tests were extended, in every case, to include an examination of their preputial washings. This examination aimed at demonstrating *Trichomonas fœtus,* bacteria and moulds, if present, and the epithelial cells resulting from surface desquamation or injury to the lining of the preputial cavity. Although the study of the last-named item was originally undertaken with the object of collecting information helpful in identifying the epithelial cells encountered in bull semen, it was later found very valuable in gauging the condition of the prepuce, particularly when its affection could not be detected clinically. Observations were also made on the incidence of leucocytes in the preputial washings. The literature does not appear to make reference to the examination or description of the epithelial cells in the preputial washings of bulls, and therefore it was decided to describe such cells and discuss their clinical importance in this paper.

Method of Washing and Examination

About 150 ml. of sterile mornal saline containing 2 per cent. glucose was pumped into the preputial cavity through a sterile Neilson's uterine catheter. The catheter was gently introduced to a depth of 6 inches or more, without causing undue annoyance to the bull. While pumping, the preputial orifice was kept closed by manual grip to prevent the outflow of the solution. After the requisite quantity of the solution had been introduced, the catheter was gently withdrawn, the orifice kept closed, and the prepuce massaged backwards and forwards with the hand, so as to ensure that the solution had thoroughly washed the entire cavity. The grip was then released and the washing collected in a beaker. The recovery of as much washing as possible was effected by a forward massage of the prepuce.

Immediately after collection, a large drop of the washing was placed on a

slide, covered with a coverslip, and examined under the microscope. A general idea about the type of cells present in the washing was obtained by examining it at the farm, while the detailed examination was carried out at the laboratory within 1-3 hours of its collection. No special precautions were considered necessary in transporting the washing to the laboratory. The washing was shaken gently and 15 ml. centrifuged at 2,000 revolutions per minute for 5 minutes. The supernatant fluid was removed by a pipette until 1 ml. of it was left in the tube. The sediment was then mixed with the fluid and a drop of this mixture was examined for trichomonads, blood cells and epithelia. Whereas the epithelial cells yielded much more information after staining than in the fresh state, leucocytes were readily studied in the fresh condition.

A thick smear was made from the sediment mixture referred to above and allowed to dry at room temperature. It was stained with hæmalum and eosin as recommended for staining sperm (Gunn *et al.*, 1942), but the staining time was modified as under:—

Methyl alcohol—fixing for 2 minutes.
Distilled water—washing gently for a few seconds.
Hæmulum—staining for 30 minutes, instead of 6 minutes recommended by Gunn and his associates.
Tap water—washing for the same time as that allowed for staining, i.e., 30 minutes, instead of 3 minutes recommended by Gunn and his associates.
Eosin—counter-staining for 2½ minutes.
Distilled water—washing gently for a few seconds.
Drying and mounting—allowing the smear to dry at room temperature, or passing it through a small flame twice or thrice, and mounting in neutral xylol-balsam.

This modification of the staining method gave a more intense staining reaction and a more distinct structural differentiation of spermatozoa as well as semen cells than the original method. Since one of us is dealing primarily with semen cells, all slides made from semen and preputial washings were stained by this method, so as to ensure a uniform picture of all kinds of cells under observation. Although in our hands the above-mentioned modification proved superior, particularly for the simultaneous staining of spermatozoa and semen cells, for the examination of preputial cells alone the smears can be stained by the original method, or with other connective tissue or even blood stains (Wright's blood stain, which was often used, did not give clear definition of the cytoplasm or the boundary of the epithelial cells).

All smears were examined under the 4 mm. objective of a Beck microscope, using x 10 ocular and 142 mm. length of the draw tube. The oil immersion lens was used only for measuring the dimensions of cells and studying their internal structure. The percentages of different types of epithelial cells were calculated by examining 300 cells on different parts of the slide, and their dimensions were averaged on the basis of 25 measurements in each case. When the number of cells of a certain type was less than 25, all the available cells on the

slide were measured. The sizes of cells of one type were compared with those of another on the basis of the area of their surfaces (Haq, 1948).

Description of Cells and Their Identification

The prepuce is lined by stratified squamous epithelium, and the various layers comprising the epithelial sheet can be grouped into: (1) superficial layers of large squamous cells, (2) middle layers of irregularly polyhedral elements, and (3) basal layers of columnar or cuboidal cells. The epithelial cells found in the preputial washings, therefore, originate in one or more of these layers, and are of three types. The cells of one type are easily distinguishable from those of another owing to differences in their morphological characteristics as described below.

(1) *Cells from superficial layers* (Plate I).

These are large squamous cells having irregular outlines. While some of them are nearly ovoid or spherical, others may have a spindle-shaped appearance (in edge view). The boundary line is often ill-defined. They average a size of 45-60 x 35-52 μ, though much larger, 140 x 46 μ, or smaller, 35 x 25 μ, cells are also found. Their cytoplasm takes a *light* stain, may show discrete vesicles or vacuoles, and is often studded with micro-organisms and debris. Both nucleated and anucleated cells are seen, the latter forming about 10 per cent. (min. 3, max 21) of the total. The nuclei, when present, are oval or spherical, 8-9 x 7-8 μ, and show various stages of nuclear degeneration—karyorrhexis and karyolysis. Some cells show small, 5 x 5 μ, hyperchromatic nuclei, while in others they take the form of large, 12 x 10 μ, indistinct nuclear remains.

(2) *Cells from middle layers* (Plate I).

These are polyhedral cells having oval, ovoid, spherical or, sometimes, pear-shaped outlines. Their boundary line is invariably shown distinctly. They measure 18-26 x 12-22 μ, although cells as large as 32 x 30 μ (from outer strata of the middle layers) or as small as 14 x 10 μ (from inner strata of the middle layers) are also seen. These cells take *medium* to *deep* stain, and are about one-fourth the size of the superficial cells, though a few may be two-thirds and many others one-tenth their size. Their cytoplasm is, as a rule, not vacuolated or studded with micro-organisms and debris. They are always nucleated, the nuclei being oval or spehrical, 7-8 x 6-7 μ. The nuclei of a few cells may, however, equal the size of those of the superficial cells.

(3) *Cells from basal layers* (Plate II.)

These are columnar or cuboidal cells having well-defined boundaries and *deeply* staining cytoplasm like those from the middle layers. They average 20-35 x 8-15 μ, though bigger, 41 x 13 μ, or smaller, 15 x 6 μ, cells may be seen. Their cytoplasm is seldom vacuolated or studded with micro-organisms and debris. They are invariably nucleated, the nuclei being elliptical or oval, 7-9 x 4-6 μ.

Relative Incidence of Cells and Their Significance

For purposes of finding out the significance of epithelial cells, preputial washing from 29 bulls were examined (Table I). They included three normal bulls, ten sterile (partial or complete) bulls having normal prepuce, nine normal or

sterile bulls harbouring *Pseudomonas æruginosa* in their preputial cavities, and seven bulls showing preputial inflammation of bacterial or trichomonad origin.

TABLE I

Incidence of leucocytes and epithelia in the preputial washings of bulls

Serial No.	Bull No.	Disease	No. of leucocytes per field	Percentage of preputial cells from superficial layers	middle layers	basal layers
		Normal Bulls				
1	M 13	———	1 (0-2)	98	2	0
2	M 14	———	0 (0-3)	100	0	0
3	M 15	———	1 (0-2)	99	1	0
		Sterile bulls having normal prepuce				
1	AB 3	Faulty erection	2 (0-5)	96	4	rare
2	AB 5	Paunchiness	1 (0-3)	97	3	0
3	AB 6	Testicular degeneration	1 (0-3)	97	3	0
4	AB 8	" "	0 (0-1)	100	0	0
5	AB 14	" "	1 (0-3)	98	2	0
6	AB 15	" "	1 (0-3)	99	1	0
7	AB 18	Hypoplasia	2 (1-4)	100	0	0
8	AB 24	Faulty erection	3 (1-5)	100	rare	0
9	AB 26	Testicular degeneration	1 (0-3)	99	1	0
10	AB 33	" "	4 (0-7)	100	1	0
		Bulls having benign infestation of the prepuce with *P. æruginosa*				
1	AB 10	———	1 (0-6)	98	2	0
2	AB 13	Paunchiness	3 (1-7)	97	3	rare
3	AB 21	Testicular degeneration	1 (0-2)	100	0	0
4	AB 22	———	1 (0-2)	100	rare	0
5	AB 25	Hypoplasia	2 (0-3)	100	0	0
6	AB 28	Testicular degeneration	4 (1-9)	100	0	0
7	AB 30	———	1 (0-4)	100	0	0
8	AB 31	Testicular degeneration	2 (1-5)	100	0	0
9	AB 32	" "	1 (1-5)	98	2	0
		Bulls having inflammation of the prepuce				
1	AB 2	Moderate inflammation	15 (5-36)	97	3	0
		2nd visit—2 months later	1 (0-4)	98	2	0
2	AB 7	Moderate inflammation	20 (6-40)	97	3	0
		2nd visit—1 month later	1 (0-5)	100	0	0
		3rd visit—3 months later	1 (0-2)	99	1	0
3	AB 12	Mild inflammation	4 (1-16)	98	2	0
4	AB 29	Chronic granular inflammation	5 (1-10)	89	11	rare
		2nd visit—20 days later	4 (0-8)	71	25	4
5	M 16	Acute catarrh	25 (16-60)	98	2	0
6	M 17	Moderate inflammation	18 (7-32)	96	4	0
		2nd visit—1 month later	3 (0-4)	99	1	0
7	M 3	Trichomoniasis	30 (22-80)	81	18	1
		2nd visit—7 weeks later	2 (0-4)	99	1	0
		3rd visit—2 weeks later	40 (30-80)	89	10	1
		4th visit—2 weeks later	60 (30-140)	85	13	2
		5th visit—1 week later	0 (0-3)	100	rare	0

NOTES.—(1) The number of leucocytes observed per field refers to the concentrated washing as explained in the body of the article. (2) The figures given in brackets refer to the minimum and maximum numbers observed in each case. (3) The prepuce was washed before collecting semen in the artificial vagina in all cases, except AB 3, 5 and 6, which were washed after the collection. No such collection was made from M 3, AB 2 and 13. (4) AB 2 harboured *Absidia corymbifera*, and AB 12 an untyped mould in the prepuce. (5) M 17 and AB 7 showed inflammation of the prepuce due to infection with *C. pyogenes* and staphylococci on the first examination but were free from it on the subsequent examinations.

Excepting the bull with *Trichomonas fœtus* infection (known to have been infected for four years), bulls in the last-named group were treated, but all were examined more than once.

(1) *Cells from superficial layers.*

These arise as a result of partial keratinisation and desquamation of the superficial layers of the preputial mucosa. In all the healthy and diseased bulls examined, by far the largest number of cells belonged to this variety. In bulls having a normal prepuce, including those showing a benign infestation with moulds,* *P. æruginosa, C. pyogenes* and cocci, these cells averaged 98 per cent. (min. 96, max. 100) of the total (Plate II). The percentage of cells remained unchanged even when the irritant involved gave rise to various stages from a mild catarrh to a moderate inflammation of the prepuce. In chronic deep-seated inflammation of the prepuce, however, these cells formed only 82 per cent. (min. 75, max. 90) of the total epithelial cells, e.g., in the cases of AB 29 and M 3. This reduction in the percentage of cells resulted from a proportionate increase in the percentage of cells from the deeper layers detailed below.

(2) *Cells from middle layers.*

These come from the middle layers of the prepuce, and constituted 2 per cent. (min. 0, max. 4) in all animals except AB 29 and M 3. Since these cells did not show an increase in cases of preputial infection with *P. æruginosa, C. pyogenes, Absidia corymbifera* and *cocci,* even when there was preputial catarrh with a fair amount of inflammatory exudate (Plate III), it was considered that infection with these organisms, at least in the early stages, was not severe enough to cause damage to the middle layers of the preputial lining.

The percentage of these cells in the case of AB 29 ranged between 11 and 25, showing that the nodular inflammation of his prepuce involved the deeper layers of the epithelial sheet. Although this bull has been stated to be suffering from chronic nodular inflammation of his prepuce, the precise cause of this affection remains undetermined, as it was not possible to isolate organisms in significant numbers, to which this condition could reliably be attributed : hence the possibility of trichomonad infection could not be ruled out.

In the case of M 3 with *T. fœtus* infection, the percentage of cells from the middle layers fluctuated from time to time. When these cells increased, they averaged 16 per cent. (min. 10, max. 22) and when such an increase was absent, the cells picture was quite normal, i.e., the cells from middle layers formed only 2 per cent. (min. 0, max. 4) of the total. This showed that whenever the inflammatory process involved the middle layers, these cells always formed 10 per cent. or more of the total cells (Plate III). Their appearance was, therefore, linked up with the severity of the reaction; the cells increased when the nodules were in an active state of inflammation involving the deeper layers, while they decreased to within normal limits when the deep-seated lesions had healed. The fact that the cells from the middle layers did not appear unless the injury was deep-seated was strengthened by observations on the appearance of red blood cells in the preputial washings. At the time of the fifth visit to M 3, although the mucous lining was scraped to a point of injury with the appearance of red blood cells in

* The mould isolated from AB 2 was *Absidia corymbifera,* while that from AB 12 has not yet been typed.

the washing, there was no abnormal increase in the proportion of cells from the middle layers.

(3) *Cells from basal layers.*

These cells come from the deep-seated layers of the mucosa and appear when the basal layers are damaged. They were only found in the washings of AB 29 and M 3, and at a time when there was an abnormal increase in the cells from the middle layers. They averaged 2 per cent. (min. 0, max. 4) of the total cells when the deep-seated lesions were present, and were rarely seen when such lesions had healed. The observations further showed that the active lesions caused by *T. fœtus* involved the basal layers of the preputial lining, though the severity of the reaction seemed limited to the middle layers, owing to the comparative preponderance of cells from those layers.

(4) *Leucocytes.*

The examination of leucocytes in the washings was an additional aid in determining the condition of the prepuce. For reasons given already, they were examined in an unstained condition. In bulls with a normal prepuce, including those having a benign infection with moulds, bacteria and *T. fœtus*, their number was 1-2 (min. 0, max. 9) per field. In the inflammation of the prepuce, however, this number was greater and bore a direct relationship to the severity of the inflammatory reaction. Thus, in cases of mild, moderate and severe inflammation their number was averaged at 4 (min. 0, max. 16), 18 (min. 5, max. 40), and 36 (min. 12, max. 140) per field, respectively. In chronic nodular inflammation, after the acute stage had subsided, the number approximated that for a normal prepuce. Although the number of leucocytes increased when the number of epithelial cells from deeper layers showed a high incidence, on rare occasions no such increase was noticed, when a mild chronic inflammation was suspected. On the other hand, when the number of leucocytes was high but there was no increase in the epithelial cells from deeper layers, the condition present was either a temporary catarrh (M 16) or an acute superficial inflammation of the mucous membrane (AB 7 and M 17). In the former case, the stained slides did not show many organisms, while in the latter, many bacteria and clumps of pus cells were clearly visible (Plate III). Many cases of preputial inflammation came to light only on an examination of the preputial washings, as there were no objective or subjective symptoms which could give a clue to the existence of an abnormality of the prepuce.

Discussion

About 150 ml. of glucose-saline was considered a more suitable quantity than smaller amounts such as 25 ml. used for washing the prepuce by some workers (Andrews and Miller, 1938), because (a) some bulls contract the preputial sphincter and withhold large amounts of the solution for a considerable time, thereby making it almost impossible to recover all the washing quickly, and (b) a small quantity is not sufficient for a thorough scrubbing of the entire preputial cavity. Larger quantities, of course, had an adverse effect on the concentration of *T. fœtus* per unit volume to some extent, but this was overcome by making a search for them in the concentrated washing after centrifugation. Glucose was

added to satisfy the carbohydrate requirements of the flagellate Andrews and von Brand, 1938), and it was considered to have beneficial effects at a concentration of 2 per cent. (Pierce, 1947).

While classifying the epithelial cells, it was sometimes found difficult to establish the identity of a few of them, as they showed deviation from the average size, shape and staining affinity characteristic of their type. The number being negligible, they were not considered for purposes of diagnosis. The epidermal scales, liable to be confused with anucleated superficial cells or those having indistinct nuclei, were distinguished by their scaly nature and indifferent staining affinity. As regards the anucleated cells, although they averaged 10 per cent. of the total number of cells from the superficial layers, a variation between 3 and 21 per cent. was not uncommon. These figures are in accord with those reported previously from a study of the preputial mucosa in sections as well as in teased preparations (Haq, 1948).

Cell counts from the washings of bulls having an inflammed prepuce clearly showed that cells from the deeper layers of the preputial mucosa appeared only when there was deep-seated damage to the lining membrane. Such damage did not seem to occur under ordinary conditions, even if there was acute inflammation causing a copious flow of purulent and evil-smelling discharge (e.g., AB 7 and M 17). On the other hand, such damage seemed to be quite a characteristic feature in M 3 infected with *T. fœtus*. The appearance of cells from the deeper layers on some occasions and their disappearance on others is explicable on the ground that the deep-seated lesions noticed in trichomonad infection appear and disappear at varying intervals (Kust, 1934; Andrews and Miller, 1938; and Pierce, 1946). In view of these observations, it appears feasible to suspect an infection with *T. fœtus* whenever the epithelial cells from the deeper layers appear and disappear at a few days' interval (as in the case of M 3), provided that the washing does not show gross bacterial infection when examined on ordinary slides or preferably on culture plates shown for the purpose. As we could not examine more bulls harbouring this flagellate, the precise relationship between the cells from deeper layers and the appearance and disappearance of deep-seated lesions could not be established. On the basis of our observations we strongly suggest that this point be investigated further, as the incidence of cells from the deeper layers is very likely to assist in diagnosing infection with *T. fœtus*, which is very often so difficult to see under the microscope.

The preputial catarrh of M 16 was not detected clinically, but became evident as a result of the examination of the washing, which showed an abnormally high leucocytic count. Since this increase in the number of leucocytes was not accompanied by an increase in the cells from deeper layers, nor was there evidence of gross infection with bacteria or *T. fœtus*, the primary cause of inflammation was considered to be a mild mechanical irritation, possibly through collecting semen into the artificial vagina. As the contamination of semen with preputial exudate has a deteriorating effect on its potentialities, and because such a catarrh cannot always be detected clinically, it seems worth while washing bulls as a routine—say once a week—to find out that their prepuce is in a healthy condition.

Summary

The paper records the method of washing the prepuce of the bull and examining the washing before and after staining as a routine measure in testing bulls. The method is recommended particularly because, in some cases, it is impossible to gauge the condition of the prepuce from objective as well as subjective symptoms, while an examination of the washing, which is easy to conduct even under field conditions, reveals the affection very readily.

The distinguishing characteristics of the epithelial cells from different parts of the preputial mucosa are described and illustrated in some detail.

From a study of the washings of 29 bulls, it is concluded that in a healthy condition of the prepuce, the cells of the superficial and middle layers of the epithelial sheet formed 98 per cent. (min. 96, max. 100) and 2 per cent. (min. 0, max. 4) respectively, there being no cells from the basal layers. This picture may remain unchanged in cases of superficial inflammation, even if there is a considerable amount of purulent discharge made up of pus cells and bacteria. In cases of deep-seated inflammation, the cells from the middle and basal layers increase, while those from the superficial layers show a proportionate reduction. The three types of cells in such cases averaged 82 per cent. (min. 75, max. 90), 16 per cent. (min. 10, max. 25), and 2 per cent. (min. 0, max. 4) respectively, depending upon the severity of the reaction and injury to the subjacent layers.

The presence of deep cells at a few days' interval in the washings which do not show evidence of bacterial infection, coupled with a granular inflammation of the prepuce, is quite characteristic of *T. fœtus* infection. Some information helpful in diagnosing the causative agent responsible for preputial affection is furnished.

Observations on the leucocytic counts of sheath washings serve as an additional aid in determining the condition of the prepuce. The number of leucocytes in the concentrated washing is averaged at 4 (min. 0, max. 16), 18 (min. 5, max. 40) and 36 (min. 12, max. 140) per field in the mild, moderate and acute inflammations respectively. The relationship between the leucocytes and the epithelial cells and bacteria of the washing is also discussed.

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REFERENCES

(1) Andrews, J., and Miller, F. W. (1938): "*Trichomonas fœtus* in bulls." *Amer. J. Hyg.*, 28 : 40.
(2) Andrews, J., and von Brand, T. (1938): "Quantitative studies on glucose consumption by *Trichomonas fœtus*." *Amer. J. Hyg.*, 28 : 138.
(3) Gunn, R. M. C., Sanders, R. N., and Granger, W. (1942): "Studies in fertility in sheep. 2. Seminal changes affecting fertility in rams." *Bull. Coun. sci. industr. Res., Australia*, No. 148.
(4) Haq, I. (1948): "Some morphological characteristics of the epithelial cells lining the genital tract of the bull." *Vet. J.*, 104 : 5.
(5) Kust, D. (1934): "Fruhabort des Rindes." *Deut. tierarztl. wochnschr.*, 42 : 439.
(6) Pierce, A. E. (1946): "Clinical observations on an experimental case of bovine trichomoniasis." *Vet. Rec.*, 58 : 16.
(7) Pierce, A. E. (1947): Private communication.

STUDIES ON THE BLOOD OF DOGS: I—THE BLOOD PICTURE IN NORMAL DOGS*

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Introduction

THE much increased use of blood examination as an important aid to veterinary diagnosis has prompted the publication of much work similar to that here reported, in Europe, America, Japan, South Africa and India, on the blood picture of several domesticated animals in health and in disease.

Very few comprehensive studies on the blood of any single species of animal have, however, been published. This is contrary to what applies to human medicine, where several excellent hæmatological treatises are available for ready reference to the student and practitioner. Canine practice has now assumed a preponderating place in the current veterinary practice of several countries. Even in Egypt, where agricultural animals are of dominant economic importance, that form of practice cannot be overlooked, especially in the large towns. It thus seemed opportune to the author to present a systematic study of the subject of canine hæmatology to serve as a guide to practitioners.

In the present work, the blood picture of some 400 dogs is described and the significance of the findings reviewed, special attention being given in subsequent studies to the changes in the blood picture provoked in the many disorders in which a knowledge of the hæmatological changes may be of great help to the practitioner in diagnosis, prognosis and treatment.

In this first paper, my purpose is to furnish data upon the blood of normal dogs as a necessary introduction to an analysis of the changes investigated in the blood of dogs suffering from some of the common diseases. In my view, the data already published are, in several respects, inadequate, and so a correct evaluation of the pathological changes cannot be made with either certainty or reliability.

Technique

The dogs used were brought by their owners to the Veterinary School hospital either as in- or out-patients. Later, stray dogs—the so-called "*balady*" dogs—of different sexes, age, size and weight were also used. In all similar work the common stray dog has been used mainly in experiments. Some of these dogs proved to be normal, even after subsequent careful clinical and post-mortem examination. Others, which were to every appearance normal, showed upon examination of their fæces, various intestinal parasites. Others showed some symptoms of illness or skin affection. They varied in weight from 5 to 20 kg., the average being about 15 kg. During their life at large, the dogs had been fed upon table scraps, kitchen refuse and bones. At the time of blood examination they were fed in the morning upon a diet consisting of milk and white bread and later in the day on beef juice, bones and white bread. They were fed *ad lib.* and supplied with fresh water daily. It is appreciated that this

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dietary would not be conducive towards maintaining the dogs at a high plane of nutrition and that consequently, as the result of obvious deficiencies in it, they might be prone to anæmia. However, it was intentionally chosen as representative of the diet of the ordinary country, or *balady*, dog of Egypt.

TIME OF INSPECTION

Blood was obtained daily at the same time, namely, between the hours of 10 a.m. and 12 noon, during the periods between the months of October and June during the two years 1940-1941 and 1941-42.

For convenience, the dogs were classified into the following age groups:—

Group I:	from birth to 3 month	= Puppies
Group II:	from 3 to 9 months	= Adolescents (young dogs)
Group III:	from 1 year to 7 years or older	= Adults

METHOD OF OBTAINING BLOOD

Blood specimens were collected from the marginal vein of the ear. The margin of the ear was clipped and not shaved. The part was then well cleansed with alcohol and ether and allowed to dry, for otherwise the blood would not form a round drop. After pricking with a sharp needle the blood was allowed to flow away one drop at a time. The first drop of blood that appeared was not used and was wiped away. The second and succeeding drops were used in all examinations. Neither anæsthetics nor any method of restraint were employed during this procedure.

No anti-coagulants or storage of collected blood were necessary as the dogs were retained for observation and supply of regular blood samples in the school hospital. By following this procedure, the blood was obtained in a condition as nearly as possible resembling that in the blood vessels.

DETERMINATION OF HÆMOGLOBIN

The Sahli-Leitz hæmoglobinometer was used in this study. The hæmoglobin content of the blood was recorded in two ways, namely:

(1) By reporting the actual number of grams of hæmoglobin in each 100 c.c. of blood.

(2) By expressing the results as a percentage of an arbitrary normal figure.

ENUMERATION OF ERYTHROCYTES

A hæmocytometer was used consisting of a double counting chamber of the Thoma-Zeiss type fitted with a cover glass and provided with red cell and white cell pipettes each with its rubber tubing and mouthpiece.

The diluting fluid, "Hayem's solution," was filtered, placed in a watch glass and covered. After the blood was obtained it was made in the usual way into a dilution of 1 to 200 in the red cell pipette, and the counting chamber then charged. In counting the cells under the microscope 5 blocks, each of 16 squares, were chosen.

ENUMERATION OF LEUCOCYTES

The same materials as for the red count were assembled, substituting a white cell pipette and a white cell diluting fluid consisting mainly of 1 per cent. acetic acid to hæmolyse the erythrocytes, and making the dilution of blood to 1 to 20.

Differential Leucocyte Count

The accuracy of differential counts may be influenced, as is well known, by several factors, among which may be mentioned:

(1) The method, care and skill with which the preparation is made.

(2) The number of cells counted.

Preparation of Blood Smears.—A fresh drop was taken on a platinum loop, quickly transferred to a slide about ½ in. from the end, and a clean thin cover glass quickly applied. As soon as the blood had ceased spreading, the tips of two fingers were placed on the cover glass which was then slid quickly along the slide leaving a thin uniform film elliptical in shape, about 2 cm. long and 1 cm. wide. The blood cells were uniformly spread throughout the film.

Staining of Blood Film.—A great variety of hæmatological stains was tried, but the one which gave the most satisfactory results and was adopted as a routine was the panoptic method of Pappenheim, following the technique outlined by Piney. It should be mentioned here that the most important factor in this method is the neutralisation of the distilled water used for diluting the stain.

The "Random Method," i.e. the counting of cells from one side of the preparation to the other side and back again until the required numbers were counted, was the only method used in this work. In cases of a high total count not less than 500 and up to 1,000 cells were counted under the oil immersion lens, and in cases of low counts not less than 300 cells.

A "Hæmogram" prepared according to Schilling was constructed for each animal, to record the cell distribution.

Measurement of the Red Cell Diameter

The procedure used in this work was as follows: In a film stained by Pappenheim's panoptic method, 200 red cells were measured in their horizontal diameter. Since only one diameter was measured it was necessary to select round cells, thus introducing a certain degree of selectivity into the results. Our measurements were made with a Zeiss No. 4.6 ocular micrometer with a Zeiss ½-in. oil immersion objective N.A. 1.25, and tube length 160 mm. All measurements were made by the author, using the same ocular micrometer, which had been calibrated on the same microscope.

Reticulocyte Count

Clean and dried slides were arranged in front of the operator, a glass rod was dipped in 1 per cent. alcoholic solution of brilliant cresyl blue and a thin layer spread over the slides and allowed to dry in the air. These slides keep indefinitely ready for use.

A small drop of fresh blood was touched on to the stained surface of a slide and a large cover glass placed over it. The slide was allowed to stand for ten minutes for complete staining. To facilitate accurate counting of reticulocytes, the ocular of the microscope was provided with a square diaphragm which was shut to accommodate a very small number of cells.

The area located was then observed under the oil immersion lens. Starting from a given point and counting adjacent fields, one thousand red blood cells

including the reticulocytes were counted. The reticulocytes in each block were recorded separately. They were then summed up and expressed as a percentage.

ENUMERATION OF BLOOD PLATELETS

Many methods of counting blood platelets have been proposed. All of these are not entirely satisfactory. The "Thomas F. Walker" (1939) method was selected for its efficacy and simplicity. The platelet count was somewhat variable in different individuals and, indeed, even in the same individual.

The Normal Blood of Dogs

The present study was undertaken to establish average indices for dogs in good health. Animals included under this heading were clinically healthy and found free from any abnormality on post-mortem examination. The experimental animals numbered 74 selected from approximately 400 stray dogs, and they were of different sexes and ages, ranging in weight from 5 to 25 kg. Most of the puppies were littered in the hospital and they were examined several times and the averages for each recorded. All these dogs were free from intestinal parasites and, according to our experience, they were in better condition than the average selected as a normal dog. They were kept in separate cages on a diet consisting of beef soup and white bread occasionally supplemented with milk; water was given freely.

Results and Observations

THE RED BLOOD CORPUSCLES

The results demonstrate the following crude figures for the normal red cell count:

Animal	Minimum per c.mm.	Maximum per c.mm.	Average per c.mm.
Puppies	3,150,000	5,920,000	4,300,000
Adolescents	3,550,000	6,770,000	4,583,000
Adult bitches	3,550,000	7,360,000	5,696,666
Adult males	3,280,000	8,700,000	5,477,000

A fair average for adults, irrespective of sex, was 5,587,000 per c.mm.

From these findings one concludes that puppies and adolescents have a low red cell count which progressively increases from three months of age to puberty. Comparison between the males and the females indicates that a slightly higher count exists in the latter. Variation of as much as one million in the red blood cell count of individual dogs within a few days was not uncommon.

Discussion.—The observed difference between the counts of adult males and females, although not confirmed by all other workers, has been tested statistically by Landesberg (1939) and found by him to be significant. Kuhl (1929), according to Scarborough (1930), also found higher erythrocyte counts in female canines. Morris and Allison (1940) agree with Mayerson (1930), who reports similar findings for the erythrocytes, hæmoglobin and hæmatocrite values. There are, however, reports in the literature (Scarborough [1930], Wintrobe [1935], and Otto according to Burnett [1908]) in which the erythrocyte count values for males have been claimed to be higher than those for the females.

Leichsenring *et al.* (1932) report that the averages for the two sexes are very similar but individual differences are relatively large. Brüner and Wakerlin (1937) also state that no significant differences were noted in the sexes.

It is generally stated that the number of red blood corpuscles is larger in the newly born and smaller in adolescents than in adults. The results now reported in this paper indicate clearly that the count in puppies is distinctly lower than that of adolescents and also of adults. According to Burnett and Traum, the average number for adult dogs is 5.9 mill. per c.mm., while puppies less than a day old to 20 days old have 3.9 to 4.1 mill. per c.mm. This agrees to some extent with the averages given here. Scarborough (1930), in his compendium upon the published blood values for normal dogs, remarks that the erythrocyte values are lower in immature animals and that they increase gradually with age.

Wells and Sutton (1915), as well as Powers, Bowie and Howard (1930), expressed the same idea, stating that the erythrocyte count and percentage of hæmoglobin of adult dogs are uniformly higher than those of man, and similar determinations on the blood of puppies are somewhat lower but they tend to approach normality towards the end of the first year of life.

Landesberg (1939) made a comparison of his own values on young dogs with the findings of others on the blood pictures in adult dogs, and found that the number of erythrocytes and the concentration of hæmoglobin were lower in his groups.

Morris and Allison's (1940) figures are in substantial agreement with those recorded here. They state that their data demonstrate that the number of red cells and the concentration of hæmoglobin increase from two months of age to puberty, which is approximately eight months in the majority of the breeds investigated. They also state that their own data taken together with those recorded previously can be interpreted to mean that in normal dogs, after puberty, the number of red cells per c.mm. is little influenced by age, sex or breed. Many authorities have noted a high percentage of hæmoglobin and a high cell count at birth. These figures rapidly fall after the first few days.

According to Whitby and Britton (1939), the red cell count drops soon after birth in children. Towards the end of the first year it has fallen to its lowest point, when the count begins to rise up to the end of the fourth year. In the new-born they say that a higher red cell count may be a compensatory polycythæmia due to the anoxæmic conditions of intra-uterine life.

Red Cell Diameter

Actual measurements are required to determine the size of the red cells. Although variability in size is easily noted on mere observation, one is apt to be misled as to the average size by the presence of even a few markedly large or small cells.

The average diameter of the red cell of the animals in this study was 8.03μ for puppies and 6.99μ for adolescents and adult dogs. From these averages, it can be stated that the average diameter of the red cell in the new-born is larger than the average diameter in the adult. This is due in great part to the presence of a large number of reticulocytes which are larger in size than the normal red cell.

Comparing these data with those of other investigators, we find them to agree fairly well with those of Manasseim (6.95) and Kohanawa (6.8) (cit. Burnett), but they are slightly lower than those reported by the following: Gulliver (1846), 7.05; Hayem, 7.2; Kracke (1937), 7.0; Sussdorf (cit. Burnett), 7.3; Welcher, 7.3; Vierordt, 7.3; and Burnett (quoting six investigators), from 6.95 to 7.3.

RETICULOCYTES

The reticulocytes, which are now proved to be young red cells, are slightly larger than the mature red cell, and contain fragments of nuclear remains. The presence of reticulocytes in the circulation is an indication of an increase in activity of the bone marrow. The reticulocyte count is of value for assessing the efficacy of treatment and for differential diagnosis.

The blood of a healthy adult dog was found to contain from 0.2 to 2.4 per cent. of reticulocytes, with an average of 1.2 per cent., which is lower than the 3.59 per cent., the average for puppies.

The circulating blood of the new-born contains a fair number of immature red cells, both nucleated cells and reticulocytes, which range from 1.3 to 7.4 per cent. The blood of adolescent and adult dogs does not normally contain nucleated cells and not more than 2.4 per cent. of reticulocytes. There is no significant statistical difference between the two sexes. The value for the combined sexes is therefore given in the following table, along with the values reported by other investigators:

Author	Animal	Minimum	Maximum	Average
Present author	Puppies	1.3	7.4	3.59
„	Adolescents	0.6	2.0	1.33
„	Adults	0.2	2.4	1.2
Brüner		0	1.70	0.44
Musser and Krumbhaar		0	1.4	0.6
Landesberg				1.36
Mayerson				1.85
Kracke		0	1.4	0.6

The reticulocyte value in this work is comparable to that of Landesberg; it also agrees fairly well with the figures given by Musser and Krumbhaar (cited by Scarborough [1926]).

The mean percentage reported here is higher than the averages found by Brüner and Wakerlin and of Kracke, and lower than that reported by Mayerson (1930).

HÆMOGLOBIN ESTIMATION

The hæmoglobin percentage and number of grams in 100 c.c. of blood were measured by Sahli's hæmoglobinometer. The more useful expression for hæmatological purposes is grams of hæmoglobin per 100 c.c. of blood. Price Jones, Vaughan and Goddard (1935) found no significant difference between the hæmoglobin content of capillary and venous blood.

The crude data recorded were:

Animal	Minimum		Maximum		Average	
	% Hb.	g. per 100 c.c.	% Hb.	g. per 100 c.c.	% Hb.	g. per 100 c.c.
Puppies ...	45	7.8	55	9.4	50.5	8.7
Adolescents ...	41	7.2	56	9.5	48.4	8.5
Adult males ...	46	8.0	75	12.8	56.1	9.6
Adult females ...	49	8.3	73	12.5	58.4	10.1

Neglecting sex differences, the average hæmoglobin content of the blood of normal adult dogs is 57 per cent.; that is, if 100 per cent. is taken as the average hæmoglobin content of the blood of an adult human, then the equivalent hæmoglobin content of normal adult dogs is 57 per cent. After birth, the hæmoglobin content of the blood is high, but after the first three months of life there is a physiologic decrease in the hæmoglobin concentration.

This has been explained in the human subject by Davidson and Leitch as the result of two factors, namely:

(1) A destruction of erythrocytes by hæmolysis. The hæmoglobin values gradually rise until the normal level is reached at about the sixth month.

(2) A decrease in bone marrow activity due to the relatively high oxygen tension of extra-uterine life.

The hæmoglobin of the body of the fœtus and of the blood of sucklings and adults was estimated in dogs and other animals by Radeff, T. (1934). He found that the body of new-born animals contains a relatively greater quantity of hæmoglobin than that of the suckling or adult animal of the same species, as shown by the following figures, given in g. per kg. body weight:

Fœtus	20—30 days old	Adult
8.74—13.38	3.12—5.47	9.33

C. E. De Camp (1936) states that in dogs the hæmoglobin content varies. He considers a hæmoglobin percentage of 80, or 40.1 g. or even above, to be normal. He reported it to be lower in puppies than in adults, and then to drop with advancing age. Low hæmoglobin values in puppies were found to approach normal towards the end of the first year of life. No significant differences were found by him to exist between male or female animals or between breeds.

After puppyhood, according to our own observations, there is a rapid reduction in the quantity of hæmoglobin. Then as the animal reaches maturity, after puberty, the number of red corpuscles increases and concurrently the concentration of hæmoglobin in the blood also increases.

The present values for the erythrocyte count and hæmoglobin concentration, compared with those reported by other investigators, show that they are slightly higher than those given by Burnett and Traum (1908) and Wells and Sutton (1915). They are slightly lower than those given by Morris and Allison (1940). Our data for adolescent and adult dogs are either below or above those given by other investigators excepting Stotzing, Vierordt and Wintrobe. Our findings also agree well with those given by Sherrington.

This low average for the red blood corpuscle count and hæmoglobin concentration recorded in the present work may be due in large part to the malnutrition prevailing among Egyptian dogs as a whole.

COLOUR INDEX

If the red cell count and the hæmoglobin content are each expressed as percentages of an arbitrary normal, a relation between them can be established, which is known as the "colour index." This relation is constant in a normal person.

$$\text{"Colour index," normal} = \frac{\text{Hb. (\% of normal)}}{\text{Red cell count (\% of normal)}} = \frac{100}{100} = 1$$

The colour index, in other words, expresses the mean hæmoglobin content of each single red cell under examination as compared with the content of a normal red cell. An increase in the index would suggest an increase in cell volume, whilst a reduction may be associated with a decrease in cell volume.

The colour index for man is calculated for a normal red cell count of 5 millions and a hæmoglobin percentage of 100.

The colour index of the blood of dogs as compared with that of man was found to range between 0.38 and 0.58.

The average colour index for normal dogs in the three age groups was: puppies 0.61, adolescents 0.54, adult females 0.52, and adult males 0.51.

The indices in normal dogs taken as a whole are only slightly above one-half the normal index recorded for man. In other words, the dog "100 per cent. colour index" is only about 0.51 to 0.61 of the human "100 per cent. colour index."

THE TOTAL LEUCOCYTE COUNT

Considerable variation was noted in different groups:

	In thousands per c.mm.		
	Minimum	Maximum	Average
Puppies	5.60	10.6	8.123
Adolescents	5.40	19.8	11.065
Adults	7.00	22.4	12.760

Comparison of the averages for males and females indicates no significant difference between the two sexes, the range of the normal for leucocytes in both sexes being very wide. There was marked variation in the leucocyte count of individual dogs.

The averages in our study for puppies and adolescents would appear to be unusually low. This may have been due in part to this bad state of nutrition. Todd and Sanford (1937) state that the leucocyte number is higher in robust than in poorly nourished individuals, and if disease be excluded, it may be taken as a rough index of the state of nutrition of the individual. Another probable cause is a decrease in the count during the sucking and weaning periods.

The average of 7.44 thousands per c.mm. for puppies agrees well with the average normal figures of 7.000 and 7.762 suggested by Lenoni, Sabrzé & Muratet and Nicholas & Cot (according to Burnett) respectively. Gradwohl (1938), Burnett and Traum (1908), Rieder, Leichsenring (1931-32) and Mundhenk (1941) report a slightly higher figure for the average, ranging from 8 to 8.86 thousands per c.mm. of blood.

The mean values and the wide variation in the number of leucocytes in dogs compare favourably with the findings of Lyon (1929) (11.75), Tallquist and v. Willebrand (1937) (12.400), Kracke (1937) (11.840), Landesberg (1936) (11.895), Morris and Allison (1940) for young dogs (12.165) and for adults (11.467), and Wells and Sutton (1915) for adults (11.0). Our findings also agree closely with those of Wintrobe *et al.* (1935). The data given by Brüner & Wakerlin (1937) (14.180), Mayerson (referred to in the compilation of Scarborough) as well as Musser & Krumbhaar (1914) (15.923) and Kohanawa (1928) (17.050) would appear to be unusually high.

Burnett quotes seventeen authorities, three of whom giving maximum and minimum figures and fourteen giving averages. The minimum, average, and maximum of the counts from twenty sources included in his tabulation are 6.000, 12.168 and 31.000, respectively. Burnett's own statement is that considerable variation in the normal number of leucocytes has been found by different investigators.

Our average is higher than that given by Leichsenring (1931-32), who reports the average for males 8.490, females 9.090 and for the two sexes 8.760. That agrees well with the average normal figure of 8.000 suggested by Burnett.

THE DIFFERENTIAL LEUCOCYTE COUNT

This was made at the same time as the total white cell count.

The average differential counts for adolescents and adults agree well with each other and, as shown in the Table, agree fairly well with those published elsewhere for adult animals.

The tendency for puppies to have a larger proportion of lymphocytes and fewer neutrophiles than adult dogs which is apparent in our data has been mentioned in Scarborough's (1930) and Morris & Allison's (1940) reviews.

Discussion.—The differential counts which Scarborough (1930) and Mundhenk (1941) reported for adult dogs agree well with the average normal count for adults reported by us.

The average given by Morris and Allison is similar to ours, but their percentage for the neutrophiles is higher than ours and Scarborough's. They admit that their high percentage may have been due to their inclusion of the transitional forms of other cells as stabs. Their average percentage of mononuclears is lower than ours.

Burnett also quotes thirteen investigators, of whom eight classify the leucocytes in canine blood in a manner permitting tabulation for comparison. Seven of these give average and one gives minimum and maximum figures. The findings recorded to date are given in the following table:—

Investigators.	Basophiles.	Eosinophiles.	Neutrophiles.	Lymphocytes.	Monocytes.
	Percentages of total leucocytes.				
Mean results compiled by Burnett from 8 workers	??	7.10	66.79	18.42	8.04
Burnett (1908) ...	rare	6.00	68.00	20.00	6.00
Scarborough (1930)	0.00	5.00	69.00	20.00	6.70

(Table continued on next page)

Investigators.		Basophiles.	Eosinophiles.	Neutrophiles.	Lymphocytes.	Monocytes.
		Percentages of total leucocytes.				
Landesberg (1936)		0.03	1.81	63.61	28.13	0.70
Kracke (1937) ...		0.70	5.00	69.00	20.00	6.10
Gradwohl (1938) ...		0.00	6.00	68.00	20.00	6.00
Morris & Allison (1940)	Adolescents	0.00	3.97	62.50	33.30	1.15
	Adults	0.00	6.43	71.27	21.72	0.67
Mundhenk (1940)		0.205	7.025	64.63	19.28	8.86
Present Author (1942)	Puppies	0.00	5.85	55.90	30.00	8.87
	Adults	0.02	5.10	67.10	17.60	10.10

NEUTROPHILES

Our findings are summarised as follows:—

	Puppies	Adolescents	Adults
	(cells per c.mm and percentage of total leucocytes)		
Minimum	2,765 — 44.3	3,822 — 54.6	2,780 — 55.0
Maximum	6,360 — 74.6	14,454 — 79.0	15,615 — 82.6
Average	4,533 — 55.9	7,670 — 69.32	8,564 — 67.1

The neutrophiles from the above data are highest in actual numbers and percentage of total leucocytes in adult dogs.

Our data for the adult agree well with those given by Burnett and the eight investigators tabulated by him, and Gradwohl. The data given by Scarborough, Kracke, and Morris & Allison are slightly higher, while those given by Mundhenk and Landesberg are lower than our average for the adult.

EOSINOPHILES

These cells, which are not so numerous as the neutrophiles, vary widely in their percentage of the total leucocytes in the circulating blood in each of the several age groups as shown below:—

	Puppies	Adolescents	Adults
	(cells per c.mm. and percentage of total leucocytes)		
Minimum	205 — 3.0	320 — 4.0	192 — 1.8
Maximum	1,078 — 14.0	958 — 11.0	1,680 — 12.6
Average	454 — 5.8	673 — 6.08	650 — 5.1

The eosinophiles thus tend to be somewhat lower in puppies than in adults and they are again somewhat lower in adults than in adolescents. The averages given by both Scarborough and Kracke agree with our data, while those given by Gradwohl and Burnett are slightly higher; those given by Mundhenk and the eight investigators tabulated by Burnett are higher than ours. Landesberg records 1.81 per cent. as an average, which is lower than ours.

BASOPHILES

These cells, the scantiest in the blood, were not demonstrable in 70 of the 74 cases examined; in the remaining four cases they were present to the extent of 0.4 to 0.89 per cent.

According to our records, the average percentages were 0.0 for puppies, 0.04 for adolescents and 0.05 for adult males.

The average number per c.mm. for the three groups were 0 for puppies, 4 for adolescents and 6 for adult males. Our data agree well with those of Landesberg (1936).

LYMPHOCYTES

Considerable variation was noted in the lymphocyte count. The average percentage was highest in puppies and lowest in adolescents, adult dogs occupying a middle position between these two groups.

	Puppies	Adolescents	Adults
	(cells per c.mm. and percentage of total leucocytes)		
Minimum	744 — 12	826 — 11	656 — 3.6
Maximum	4,452 — 42	3,168 — 23	4,480 — 27.4
Average	2,437 — 30	1,720 — 15	2,246 — 17.6

Morris and Allison have reported 33.30 per cent. of lymphocytes for adolescents, which agrees well with our data for puppies, and 21.72 per cent. for adult dogs, which is higher than our findings for adults. Our figures agree fairly well with the average of the data of the eight investigators tabulated by Burnett, but they are lower on the whole than those of other investigators.

MONOCYTES

Our figures were :—

	Puppies	Adolescents	Adults
	(cells per c.mm. and percentage of total leucocytes)		
Minimum	281 — 3.7	378 — 5.0	229 — 2.7
Maximum	2,035 — 19.0	2,624 — 16.4	2,678 — 27.0
Average	699 — 8.87	1,005 — 9.08	1,289 — 10.1

These figures are much higher than those given by Landesberg, and by Morris & Allison, which are very low.

THE SCHILLING INDEX

Schilling's (1911) classification depends basically on the relative age of neutrophiles and the percentage falling into the various age groups. Unlike the Arneth grouping, which depends upon the numbers of nuclear segments, Schilling's classification recognises myelocytes, juveniles, stabs and segmented forms, as descriptive terms referable to progressive age in the neutrophiles. It is probably more accurate in practice than the method of Arneth.

The mother cell of the neutrophilic granulocyte being the neutrophilic myelocyte with a rounded nucleus, the first stage towards polymorphism in this nucleus is a slight indentation. This is the young form or "juvenile." Afterwards the indentation becomes greater, so that the nucleus is sausage shaped, and to this cell the name "band" or "stab" is given. Finally, with deeper indentation the nuclear mass becomes distorted until lobes are formed and to this stage the words "adult polymorph" or "segmented neutrophile" are applied.

In the peripheral blood of the normal puppies and adult dogs examined in this study, myelocytes were totally absent and the juveniles were also very scanty.

The table on next page shows the minimum, maximum and average of the neutrophilic percentage according to Schilling's classification.

Groups of Animals.	Myelocytes. Min.	Max.	Av.	Neutrophiles. Juveniles. Min.	Max.	Av.	Stabs. Min.	Max.	Av.	Segmented. Min.	Max.	Av.
Puppies	0	0	0	0	5.2	1.45	3.3	11.3	6.24	38.3	56	47.65
Adolescents	0	0	0	0	0.6	0.06	2.3	18.0	7.19	52.3	72	61.87
Adults	0	0	0	1	2.0	0.20	2.0	12.0	5.50	49.3	78	61.30
Adults	0	1	0.25	0	3.0	0.75	4.0	14.0	6.00	55.0	73	63.00

(After Mundhenk)

Unfortunately, the literature does not contain any reference to this count in dogs. It is only lately that Mundhenk, R. L. (1941) has recorded the count for ten normal dogs giving the minimum, maximum and average as included also in the table. The importance of this index will be discussed in the subsequent parts of these studies dealing with the pathological hæmatology of dogs.

ENUMERATION OF PLATELETS

The blood platelets or thrombocytes, which are intimately connected with the process of coagulation, this appearing to be their chief function, are difficult to count. This difficulty arises through the rapidity with which they disintegrate and their strong tendency to adhere to foreign bodies or to each other.

The platelets were enumerated for all normal dogs, males and females. Since the number is not significantly different for the two sexes, the mean values were established for the combined groups.

The average numbers of 223,300, 246,300, and 268,400 per c.mm. for puppies, adolescents and adult dogs, respectively, are higher than those reported by Landesberg (1939) (154,879), and Wintrobe (1929) (150,000), Mayerson (1930), Scarborough (1930), Kleinberger (1927), Loesch *et al.* (1924) and Kruger & Schultz (1925), but they are lower than the figure (350,000) recorded by Kracke (1937).

The marked variations in the platelet count reported in the literature may be dependent upon variations in the technique used by different investigators :—

Investigator.	Animal.	Minimum, 000's.	Maximum, 000's.	Average, 000's.
Present study :	Puppies	160	223.3	280
	Adolescents	215	246.3	286
	Adults	170	268.4	320
Landesberg :	Adolescents		154.8	
Wintrobe :	Adults	90	150.0	230
Kracke :	Adults		350.0	

Summary and Conclusions

A study of the blood cytology of 74 normal dogs of different ages, breeds and sexes was undertaken to establish normal indices for dogs.

These normal dogs were selected from about 400 apparently healthy stray dogs and fed on diet fairly representative of the food ordinarily available to dogs in Egypt. The cases included puppies between 15 and 90 days, adolescents (young dogs) from 3 to 12 months, and animals over a year in age, the latter being considered adults. The weight ranged from 5 to 25 kg.

THE RED BLOOD CORPUSCLES

The data obtained demonstrated that the red blood cells increase in number per c.mm. from an average of 4,000,000 cells for puppies to an average of about

4,500,000 for adolescents, to an average of about 5,400,000 for adult males and 5,600,000 for adult females. This denotes :—

(1) Puppies have a relatively low red cell count which increases from three months to puberty.
(2) A slightly higher count then occurs after sexual maturity is reached in both sexes.
(3) Considerable variations in the counts of dogs estimated at different times and among the dogs in a particular age group are not uncommon.
(4) The general average count of the red blood cells is lower than that reported by most investigators, which may have been caused in part by the relatively poor state of nutrition of the dogs in our study.

HÆMOGLOBIN

The hæmoglobin concentration was 50.5 per cent. (relative to a 100 per cent. normal human standard) or 8.7 g. in 100 c.c. of blood for puppies, 48.4 per cent. or 8.5 g. for young dogs, and 57 per cent. or 9.8 g. for adults. The following observations emerged :—

(1) There is a wide normal range and much variation also among individuals.
(2) Within the first three months of life there is a physiologic decrease in the hæmoglobin concentration.
(3) The hæmoglobin values then rise to the normal level, which is reached at about the sixth month.
(4) The dogs examined had a lower average hæmoglobin content in their blood than has been reported generally by other workers.

COLOUR INDEX

The chief points observed were :—

(1) The "colour index" values were 0.61 in puppies, 0.54 in young dogs, and 0.51 in adult dogs.
(2) The highest index was shown by puppies and the lowest by adult males.
(3) The indices as a whole were only slightly higher than one-half the index recorded as normal for man.

RED CELL DIAMETER

The average was between 6.9 and 8.0μ. The diameter was larger in puppies than in adults.

RETICULOCYTES

There was no significant statistical difference between the two sexes. The mean average in puppies was higher than that of adults.

THE TOTAL LEUCOCYTE COUNT

(1) The mean values per c.mm. were 8,123 for puppies, 10,446 for young dogs, and 12,762 for adult dogs.
(2) No significant difference was found to exist between the two sexes.
(3) The average found for puppies was strikingly low.

THE DIFFERENTIAL LEUCOCYTE COUNT

(1) No significant difference was found to exist between the counts for the male and female groups.
(2) The averages of the young and adult dogs agreed well with each other.
(3) Puppies tended to have a larger proportion of lymphocytes and fewer polymorphonuclears than adults.

NEUTROPHILE GRANULOCYTES

Myelocytes were totally absent from the normal blood of dogs, juveniles were scanty; segmentation of the nucleus was not so pronounced as in man. The mean average percentage ranged between 55.9 and 69.32 per cent of the total leucocytes.

EOSINOPHILES

These were not so numerous as the neutrophiles and lymphocytes. No great difference existed between the different groups. They averaged between 5.08 and 6.08 per cent. of the total leucocytes.

BASOPHILES

These were found to be absent from the blood of puppies and very scanty in the other groups. The average percentage ranged between 0.02 and 0.05 per cent.

LYMPHOCYTES

Considerable variation was noted, the average percentage being 30 per cent. for puppies, which is much higher than the average of 17.6 per cent. observed in the adult.

MONOCYTES

Our data are higher than those given by other investigators. The average found for puppies, young dogs, and adult males, which lay between 8.87 and 9.08 per cent., were lower than the average percentage found for adult females (11.8 per cent.).

SCHILLING INDEX

Myelocytes were totally absent from the peripheral blood of dogs. Juveniles were between 0.2 and 1.45 per cent, stab forms between 5.45 and 7.19 per cent., and segmented cells between 47.65 and 62.3 per cent. of the total leucocytes.

PLATELETS

The platelet count was very variable in different individuals and even in the same individual, the average ranging between 223,000 and 270,000 per c.mm.

REFERENCES

(1) Brüner, H. D., and Wakerlin, G. E. (1937): *Proc. Soc. Exp. Biol. & Med., 36,* 667.
(2) Burnett, C. H. (1908): "The Clinical Pathology of the Blood of Domesticated Animals."
(3) Davidson, L. S. P., and Leitch, I., cit. Kracke and Garver, p. 111.
(4) De Camp, C. E. (1936): *N. Amer. Vet., 17,* 22.
(5) Gradwohl, R. B. H. (1938): "Clinical and Laboratory Methods and Diagnosis," St. Louis, C. V. Mosby Co., 2nd ed.
(6) Gulliver (1846), cit. Burnett.
(7) Kleinberger (1927): "Die Blutmorphologie," Leipzig, Barth.
(8) Kohanawa, C. (1928): *Folia Hæmatologica, 36* (2), 174.
(9) Kolmer and Boerner (1931): "Approved Laboratory Technique," New York and London, D. Appleton & Co.
(10) Kracke, R., and Garver, H. E. (1937): "Diseases of the Blood and Atlas of Hæmatology," Philadelphia, J. B. Lippincott Co.
(11) Kruger and Schultz (1925), cit. Landesberg.
(12) Krumbhaar, E. B. (1922): *J. Lab. & Clin. Med., 8,* 11.
(13) Landesberg, G. W. (1937): *Amer. J. Hyg., 26,* 60; (1939) *J. Amer. Vet. Med. Assoc., 94,* 595.
(14) Leichsenring, J. M., *et al.* (1931-32): *Amer. J. Physiol., 99,* 391.
(15) Loesch *et al.* (1924), cit. Landesberg.
(16) Lyon, E. C. (1927): *J. Amer. Vet. Med. Assoc., 92,* 11.
(17) Manasseim, cit. Burnett.
(18) Mayerson, H. (1930): *Anat. Rec., 47,* 239.
(19) Morris, M. L., and Allison, J. B. (1940): *J. Lab. & Clin. Med., 25,* 353.
(20) Mundhenk, R. L. (1941): *North Amer. Vet., 22,* No. 3.
(21) Musser, J. H., and Krumbhaar, E. B. (1914): *Folia Hæmatologica, 18,* 575.
(22) Nicholas and Cot (1905): *Arch. Med. Exper. et Anat. Path., 16,* 164.

(23) Piney, A. (1931): "Recent Advances in Hæmatology," London, J. A. Churchill, 3rd ed.
(24) Powers, L. H., Bowrie, M. A., and Howard, I. M. (1930): *Amer. J. Physiol, 92,* 665.
(25) Price-Jones, Vaughan, J. M., and Goddard, H. M. (1935): *J. Path. & Bact., 40,* 503.
(26) Radeff, T. (1934): Abstr. in *The Vet. Bulletin* (1935), *5,* 386.
(27) Sabrzé and Muratet, cit. Burnett.
(28) Scarborough (1930): *J. Biol. & Med.* (Yale), *3,* 359.
(29) Schilling (1929): "The Blood Picture" (Gradwohl's translation), C. V. Mosby Co.
(30) Tallquist and Willebrand, V. (1900): *Scand. Arch. f. Physiol., 10,* 37.
(31) Todd, J. C., and Sanford, A. H. (1937): "Clinical Diagnosis by Laboratory Methods," Philadelphia, W. B. Saunders Co.
(32) Walker, T. F., and Sweeny, P. A. (1939): *J. Lab. & Clin. Med., 25,* 103.
(33) Wells, J. J., and Sutton, J. E. (1925): *Amer. J. Physiol., 39,* 31.
(34) Whitby and Britton (1939): "Disorders of the Blood," London, Churchill.
(35) Wintrobe, M. M. (1929): *J. Lab. & Clin. Med., 15,* 287; (1932) *J. Lab. & Clin. Med., 17,* 899; (1933) Amer. *J. Med. Sc., 185,* 58.
(36) Wintrobe, M. M., Shumacker, H. B., and Schmidt, W. J. (1936): *Amer. J. Physiol, 114,* 502.

FOOD AND ANIMAL PRODUCTS

By JAMES McCUNN, M.R.C.V.S., L.R.C.P.

AT the present time there is much talk about food, talk impelled by the fear of want. Scientists, politicians and, indeed, all and sundry, have joined in the general clamour. Sometimes we are warned; sometimes, and by the same individuals, we are borne upon a wave of optimism; but the ordinary man in his thoughtful moments knows that the average intake of food is much below an optimal level. Indeed the level is below that of the war years and much below what medical men considered to be the basic minimum in the 1930's.

We are threatened by a still lower scale. This lowering of intake is not only one of quantity but, unfortunately, of quality and variety. Scientists, especially chemists, juggle with the figures of calorific values and do their best to persuade us that things are not so bad as they are painted. Indeed, some would assure us that we are better fed than before the war. They may delude themselves, but they cannot delude the people.

We would observe that the animal body is not a test tube or a steam boiler, and estimates cannot be made in the same way as a maintenance engineer assesses the requirements and output of his machines or furnaces. Engines and furnaces are built to specific design and are of exact mechanical standard. The mean requirements of one may be adopted to others of the same type. But even in these cases, the methods of stoking and the quality of the fuel has a great influence on output.

The animal body is the most wonderful machine in the world, but for a variety of reasons it does not conform to such specific standards of quantity or quality, either of intake or output. Much depends on the individual. What may be too much for one may be too little for another, even when these individuals are of similar physical standard. Any man who has had charge of a flock, a herd or a stud could supply proof of this statement.

Since 1939-40, the people have been on rations. These rations have been scientifically computed to supply average requirements. On the whole they have been sufficient to provide for the body's minimal physical requirements. There has been little opportunity to build up a body reserve. There has been no joy in

them. They have lacked in variety, palatability and aroma, and in all those things which make eating a pleasure. There is no doubt that these latter things have a great bearing on good nutrition. They improve appetite and digestion and by inducing a feeling of well-being fortify the body against disease and enable us to work with a zest.

Food which does not please the senses loses much of its value. If this was not so, no doubt we should all live on tablets and pills. Unpalatable food may lead to a lowering of intake and sow the seeds of malnutrition. Now, the pleasing, delectable, appetite-stimulating and nourishing foods are in many cases of animal origin. They contain proteins and fats. There is no doubt that in the present scales of rations these things—i.e., proteins and fats—are in amount far too near the danger line.

The people want more meat, milk, eggs, butter and cheese. If the rations of these things could be increased by 50 per cent., untold benefit would result. Good food breeds happiness. Gone would be much of the present-day lassitude, despondency and unrest. The queues would vanish, the shopkeeper's back would straighten again, and black market operators would be forced to retire.

Now, these things can be provided in great part by the farmers in our own land. The farms should be able to produce all the milk, eggs, cheese and poultry that we require, and go a long way to provide for meat and butter.

To do this, farmers must turn more and more to stock-keeping and away from grain. We can get all the grain we require from our kinsmen overseas. It is better to import grain and turn it into animal protein and fat on our own farms than to import the dead product.

There should be little need to turn to alien sources. Twice in the last 30 years our Empire kinsmen have come to the rescue of the Motherland in her hour of need, and in our turn we of the Motherland should do all we can to foster and encourage Empire trading. It should be one for all and all for one in peace as well as in war.

Now, such schemes as these revolve about stock. Stock to supply immediate needs at home, to populate our lands overseas, to keep land fertile, and to build up within the Empire a great animal products industry. There must be a great increase in our flocks and herds, but to attempt this only is fraught with danger. An animal or stock policy must be based on judicious selection, adequate nutritional standards, a quickening of maturity, high fertility, and the control and prevention of disease.

To implement such a policy, the veterinary surgeon is an essential factor. By virtue of his sound scientific training he is the man to guide and instruct the stock raiser. Such schemes will fail if the profession does not rise to the occasion. There is much to do at home, there is much to be done overseas. There should be intimate and frequent contacts with our colleagues overseas. Why not have Empire Veterinary Congresses? Why not institute Empire Veterinary Scholarships, so that graduates, and especially the young men and women, could by such a system of interchange build up such a fount of knowledge as would be the envy of the world?

XUM

OBITUARY

JOHN ARCHIBALD WATT DOLLAR, F.R.C.V.S., F.R.S.E.

TWENTY ONE years ago two men decided to retire, and so was ended the veterinary practice of the Dollars in London. This practice, founded by Thomas Aitkin Dollar in the 1850's, had long been held in great fame not only in the metropolis but in all parts of the world where veterinary matters might be discussed. Only the best was good enough for the Dollars, and J.A.W. and his brother William carried on the tradition so soundly founded by their father, the great Thomas Aitkin Dollar, the ardent disciple and friend of Principal Dick. The Bond Street premises became a "Mecca" for veterinary surgeons, for here were to be found splendid premises, up-to-date equipment and a service second to none. The veterinary visitor would be received with the greatest courtesy and his search for knowledge amply gratified.

Thomas Dollar did not establish his practice easily. He met with great opposition from the established London practitioners and from those holding high positions in the profession. He held the certificate of the Highland and Agricultural Society and so was counted as below the salt by his M.R.C.V.S. contemporaries. However, he was a man of great courage, skill and integrity, and eventually he wore down all opposition so that by 1880, when he was admitted M.R.C.V.S. on payment of the registration fee, he had so turned opposition into regard that he was elected Vice-President of the R.C.V.S. From that time the name of Dollar counted high in the councils of the profession.

J. A. W. Dollar was the son of this remarkable man, being born on November 26, 1866, at Lewisham. His mother, Christina Mayer Dollar, came from Hull.

His childhood (1869-71) was spent at Wells Farm House, East Acton, and later, from 1871-1907, he lived at 56, New Bond Street. He was educated at preparatory schools in Duke Street, North Audley Street and Mount Street, London. From 1874-79 at Dollar Academy, Clackmannanshire, and from 1879-81 at Clydesdale College, Hamilton, Lanarkshire. It is recorded that he gained prizes for physiography and art. In 1882 he accompanied his mother to Canada in order to visit his maternal grandparents. On his return, he was put to work in the practice, book-keeping and helping in the dispensary. At the same time, he studied for the preliminary examination of the R.C.V.S. and matriculated in 1883, attaining first place on the list.

He entered the R.V.C. in 1884 and was attached to Professor R. V. Tuson as student assistant in chemistry. He also attended classes in German, physiology and public speaking at King's College. He was awarded prizes for German and public speaking. He qualified M.R.C.V.S. in 1887, and during his studentship gained prizes in botany, chemistry, physiology, cattle pathology, equine pathology and *Materia medica.*

In 1887 he attended Professor Crookshank's advanced course in bacteriology at King's College. This was probably the first course on such a subject to be given in the British Isles.

In 1889 came his first visit to the Continent. He visited Lyons Veterinary College, where his brother, W.W.D., had been trained.

In 1892-93 he attended courses at the Berlin Veterinary College and at Kochs Laboratory in Berlin. In the winter vacation he toured Germany, Austria, Hungary and Czecho-Slovakia.

In the summer of 1893 he attended courses at the Pasteur Institute in Paris and at the Alfort Veterinary School.

In the autumn of 1893 he made another continental tour, visiting Switzerland, Italy, Austria, Hungary, Belgium and Germany. In 1884, accompanied by his brother W.W.D., he attended the International Congress of Hygiene and Demography held in Budapest, visiting en route Paris, Lyons, Geneva, Nuremberg and Brussels.

It will be seen that Dollar was educated in no mean fashion, his continental perambulations resembling the "grand tours" which were such a feature of a gentleman's education in earlier days. No doubt his wise old father had much to do with the scheme, for it is interesting to note that his elder brother, W.W.D., also pursued a course of training at Lyons Veterinary College. The wealth of knowledge on the Continent was made available to him, and to his credit he took full advantage and, like Fleming, took steps to place the knowledge so acquired at the service of his less fortunate professional brethren. He became on intimate terms with many famous continental veterinary surgeons, and there is no doubt that for many years these people thought of the English veterinary profession mainly in terms of "Dollar." He was active in the family practice, particularly turning his attention to surgery, and under his hand the Bond Street premises became a first-class hospital, probably in its period the best equipped in the world. He also turned his hand to the pen, and between 1895 and 1912 he had to his credit a continuous flow of publications, many of which had attained classic rank. Some, such as "Moliers Surgery," were translations; some, such as the handbook on horse shoeing, were in collaboration with others; whilst "The Atlas of Veterinary Surgical Operations" and "The Practice of Veterinary Surgery," were the product of his own fertile brain.

Shortly after he qualified M.R.C.V.S., McFadyean came to the London College. It had been thought by some that Dollar had been especially schooled for this post, but this was evidently not so for there is no doubt that the Dollars were largely instrumental in the transference of McFadyean from Edinburgh to London. There is no doubt that T.A.D. worked hard for McFadyean, and it is said that his protégé only gained the post by a majority of one vote. Subsequent events fully justified T.A.D.'s wisdom.

There is no doubt also that McFadyean exerted a great influence on J.A.W.D., especially in the latter's early years. In his later years they did not see eye to eye. Two resolute men holding opposite opinions clashed and Dollar resigned from the R.C.V.S. council. In 1904 Dollar was editor of the "Veterinarian," and, when the journal amalgamated with "The Journal of Comparative Pathology and Therapeutics," he became co-editor with McFadyean. He was an active member of the Central Society, being president 1897-8 and 1898-9. He was elected to the council of the R.C.V.S. and in 1904, at the age of 38, was elected president. His chief sponsor was McFadyean. He holds the record for being the youngest man

J. A. W. Dollar

(*Taken in* 1940)

to be elected president of that body. According to the records, one finds that Dollar was often at discord with the majority; he was forceful in debate, and sometimes feelings would run high. Particularly was this so during the discussions in the early years of this century, anent the institution of an annual fee as a means of restoring the gradually diminishing finances of the R.C.V.S. to a more salubrious level. Away from the debate apparently Dollar bore no malice, and he strove to enhance the dignity and prestige of the R.C.V.S. It was through his efforts that the president of the R.C.V.S. is garbed in a manner fitting to his high office. The magnificent presidential chain and medallion were a gift from him. Professor W. O. Williams provided the mace, and the council as a whole subscribed to provide the presidential robes.

In 1900 he was elected assistant to the Worshipful Company of Farriers, one of the most ancient of the City Companies. In time he passed through the offices of Renter Warden, Middle Warden and Upper Warden, but owing to a disagreement about a proposed registration scheme for farriers, he declined the invitation to Mastership of the Company in 1903. All regretted this decision, for he had done good work for the company, work which is recognised and appreciated even to-day.

In 1904 he was elected a member of the Royal Institution, his sponsors being Sir Victor Horsley, Sir J. Crichton-Browne, Sir J. Dewar and Sir William Crookes. Such an array of supporters, each of international renown, is an indication of the regard that great men in other scientific callings had for J.A.W.D. In 1905 he was elected a Fellow of the Royal Society of Edinburgh. Dollar was held in high regard by other bodies and also in countries other than his own, and he brought renown to his profession.

He was: Membre Correspondent de la Société Centrale de Médécine Vétérinaire de Paris; Corresponding Associate of the Society of Veterinary Medicine of Brabant (Belgium); Corresponding Associate of the Royal Italian Society of Hygiene (with medal); Corresponding Associate of the Royal Spanish Society of Arts, Veterinary Section (with medal); Member of Council of the Society for the Advancement of Medical Research; Vice-President of the National Association for the Prevention of Consumption and Examiner in Languages for the Fitzwygram Prize of the R.C.V.S.

In 1917 he was elected a Visitor of the Royal Institution. He represented the R.C.V.S. at the International Veterinary Congress at Baden-Baden (1899), also at the International Congress of Hygiene and Demography at Madrid (1898), and jointly with Sir John McFadyean at the International Congress at Budapest (1905).

Dollar was a big, strong, handsome, upstanding man with a fine bearing and courteous manner. He attracted attention in any company. Forceful, even pugnacious, in debate, a man who, having formed an opinion, pursued it to the end. He was gifted in speech and with the pen. In spite of this, we are told by one who knew him well that he was by nature rather shy and retiring. He was greatly interested in engineering and in railways in particular. His first urge was to be an engineer and the attraction remained throughout his life. He took a deep interest in architecture, painting and drawing, and was an accomplished black and

white, water colour and oil colour artist. He took a great interest in photography and could and did make his own photographic equipment. He made his own lantern slides and prints until about 1939. Photography was his chief hobby for many years.

He made a telephone within six months of the description of the instrument by Graham Bell and devised several new types of microphone which have since been used in modern instruments. He also described depolarising agents now used in Leclanche dry batteries.

His chief sport was fencing. He was a member of Salle Tassart and a winner of the Deigne Cup. At heart he was a true Londoner with an intense interest in its history, buildings and inhabitants. He was a man who loved his home and particularly his garden.

The writer was unfortunate in never having contact with Dollar whilst he was in his prime and active in his profession, but one day he was privileged to act as host to him and Professor Macqueen for a few hours. They were soon in active argument with the writer sitting back as a delighted spectator. Both men were great men, and although nature has taking toll of their frames it was evident that she had failed to dull their brains. This first and last close contact with Dollar unmistakedly revealed why he had "bestrode his contemporaries like a colossus." My delight in the experience was tinged with some sorrow, for why did this man who had done so much, meant so much and was capable of still doing more for his profession retire so completely from his professional activities in 1926, when he was at the zenith of his power? Was it because he, who had shown such vision, thought that the profession was doomed to a decline with the exodus of the horse? It is significant that although his son, A. T. J. Dollar, expressed a desire to follow the family calling, he was dissuaded by J.A.W.D. from so doing and advised to follow an entirely different line.

In his old age, Dollar lost none of his courage. Early in the war he and Mrs. Dollar evacuated to Scotland. They were not happy. They sighed for London and their friends, and returned to their bomb-damaged home in Maida Vale to brave all the terrors of the Hun.

Towards the end he was afflicted with an incurable complaint, yet he bore his burden with the fortitude that one would expect of him.

He has left a widow, née Miss Violet Smart Hammond, of Putney, whom he married in 1907; two sons, A. T. J. Dollar, Lecturer in Geology at Glasgow University, and I. W. M. Dollar, Secretary at the British Embassy in Brussels; and one daughter, L. V. Dollar, at present a medical student in London. To them we tender our sympathy and the thanks of the profession for the life and work of one of our great men.

Often men leave this world without any tangible recognition during their life that they have earned the approbation of their fellows. It is good that this was not so in the case of J. A. W. Dollar.

In 1940, when he was 74 years of age, he was elected, in recognition of his eminent services to veterinary science, to be a Fellow of the Royal College of Veterinary Surgeons. This honour gave him very great pleasure. J.McC.

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